APPENDIX B

Estimation of Mule Deer and Pronghorn Maximum Survival Rates Between Ages 4-6 Months and 16-18 Months From Wyoming Game and Fish Department Herd Composition Data

Estimation of Mule Deer and Pronghorn Maximum Survival Rates Between Ages 4-6 Months (pronghorn) or 16-18 Months (mule deer) From Wyoming Game and Fish Department Herd Composition Data

I. Computations modified from techniques developed by White *et al.* (1996)

A. Notation:
- N, population size
- S, survival rate
- $(1 - S)$, mortality rate
- x, count variable of animals
- p, probability of sampling animals during counts

with subscripts:
- 1, counting time (herd composition survey) when fawns are 4 months (pronghorn) or 6 months (mule deer) old, before their first winter
- 2, counting time (herd composition survey) when fawns have are 16 months (pronghorn) or 18 months (mule deer) old, before their second winter
- 3, time duration between time = *1* and time = *2* when animals die during which carcasses can be found and counted
- f, fawns (4-6 months old) to yearling status (16-18 months old)
- d, does, 2 years old and older

B. Count variables expressed as expectations in terms of N and S

1. Count of fawns before first winter (4-6 months old), $x_{1f} = N_{1f} \times p_{1f}$

2. Count of does (2+ years old) at the same time, $x_{1d} = N_{1d} \times p_{1d}$

3. Count of fawns before second winter (16-18 months old), $x_{2f} = N_{2f} \times p_{2f} = N_{1f} \times S_f \times p_{2f}$

4. Count of does (2+ years old) at the same time, $x_{2d} = N_{2d} \times p_{2d} = N_{1d} \times S_d \times p_{2d}$

5. Count of fawn carcasses during the time interval between their 1st and 2nd winters,
$x_{3f} = N_{3f} \times p_{3f} = N_{1f} \times (1 - S_f) \times p_{3f}$

6. Count of doe carcasses (2+ years old) during the same time interval,
$x_{3d} = N_{3d} \times p_{3d} = N_{1d} \times (1 - S_d) \times p_{3d}$

II. Three ratios, A, B, and C are developed from these 6 count variables:

$$A = \frac{\text{fawns counted } (x_{1f}) \text{ at } t=1}{\text{does counted } (x_{1d}) \text{ at } t=1} = \frac{N_{1f} \times \hat{p}_{1f}}{N_{1d} \times \hat{p}_{1d}}$$

$$B = \frac{\text{fawns counted } (x_{2f}) \text{ at } t=2}{\text{does counted } (x_{2d}) \text{ at } t=2} = \frac{N_{2f} \times \hat{p}_{2f}}{N_{2d} \times \hat{p}_{2d}} = \frac{N_{1f} \times S_f \times \hat{p}_{2f}}{N_{1d} \times S_d \times \hat{p}_{2d}}$$

$$C = \frac{\text{fawn carcasses counted } (x_{3f}) \text{ at } t=3}{\text{doe carcasses counted } (x_{3d}) \text{ at } t=3} = \frac{N_{3f} \times \hat{p}_{3f}}{N_{3d} \times \hat{p}_{3d}} = \frac{N_{1f} \times (1 - S_f) \times \hat{p}_{3f}}{N_{1d} \times (1 - S_d) \times \hat{p}_{3d}}$$

III. Ratios used to estimate survival rate

A. Define λ as $$\lambda = \frac{N_{1f} \times p_{1f}}{N_{1d} \times p_{1d}}$$

and assume $$\frac{p_{1f}}{p_{1d}} = \frac{p_{2f}}{p_{2d}} = \frac{p_{3f}}{p_{3d}}$$

B. Now the three ratios are

$$A = \frac{x_{1f}}{x_{1d}} = \lambda$$

$$B = \frac{x_{2f}}{x_{2d}} = \lambda \times \frac{S_f}{S_d}$$

$$C = \frac{x_{3f}}{x_{3d}} = \lambda \times \frac{1 - S_f}{1 - S_d}$$

C. Combining equations A and B gives

1. $S_f = S_d \times \frac{B}{A}$

2. If no fawn and doe carcasses are counted, then the maximum fawn survival rate, $S_{f\text{-}max}$, can be estimated by assuming no adult doe mortality or 100% survival during the period from $t=1$ to $t=2$, by setting S_d equal to 1.

$$S_{f\text{-}max} = \frac{B}{A}$$

3. If carcasses are counted, then survival rates of fawns and does can be estimated as

$$S_d = \text{Survival Rate}_{\text{does 2+ years old}} = \frac{C - A}{C - B}$$

$$S_f = \text{Survival Rate}_{\text{fawn-yearling status}} = \left[\frac{C - A}{C - B}\right]\left[\frac{B}{A}\right]$$